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The Impact of the Coronavirus Crisis on the European Union: A Spatial Autocorrelation Analysis

Igor Y. Okunev[1],
Ekaterina Y. Arapova[2],
Yulia A. Nikitina[3]

[1, 2, 3] *MGIMO-University, Moscow, Russian Federation*
[2] *e.arapova@my.mgimo.ru*

Abstract. The authors approach COVID-19 as a perfect stress test for revealing integration connectivity within the European Union. The current crisis has challenged the resilience of regional integration, and reveals the economic connectivity within the integration blocks and their consolidating power. The goal of the research paper is to analyze the collective behaviour of the integrating countries during the external epidemiological crisis and their capability to respond to the manifestations of the crisis as 'an organic whole'. The authors develop the existing academic discourse on the de-facto effects of integration and the relationship between the national and collective interests of the integrating countries, which has become the subject of fierce controversy during the pandemic. The research is based on the original concept of the stability of regional integration during the period of external crises associations proposed by the authors. To achieve the research goal of determining the degree of spatial correlation, the authors calculated Moran's Spatial Autocorrelation Index and the multi-factor Geary's Index. The spatial and econometric analysis of the EU countries in times of COVID-19 made the authors conclude that the initial EU's response to the pandemic reflected nationalist self-help strategies rather than joint European approach during the earlier stages of the pandemic. Nevertheless, the EU demonstrated relatively strong intraregional trade resistance and ability to mitigate the negative consequences of the COVID-19 pandemic.

Keywords: spatial analysis, regional integration, Europe, COVID-19

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Влияние пандемии на Европейский Союз: пространственный корреляционный анализ

Игорь Юрьевич Окунев[1], Екатерина Яковлевна Арапова[2], Юлия Александровна Никитина[3]

[1, 2, 3] *МГИМО МИД России, Москва, Россия*
[2] *e.arapova@my.mgimo.ru*

Аннотация. Авторы рассматривают пандемию COVID-19 в качестве стресс-теста для выявления интеграционных связей внутри Европейского Союза. Текущий кризис бросает вызов устойчивости региональной интеграции, раскрывает степень экономической связанности внутри интеграционных блоков и их консолидирующую силу. Цель исследования – анализ коллективного поведения интегрирующихся стран в условиях внешнего эпидемиологического кризиса и их способности реагировать на проявления кризиса как «единого целого». В работе авторы развивают существующий академический дискурс о реальных эффектах интеграции и соотношении национальных и коллективных интересов стран – членов интеграционных объединений, ставший предметом ожесточенных споров в период пандемии. Авторы отталкиваются от оригинальной, предложенной ими концепции устойчивости региональных интеграционных объединений в период внешних кризисов. Для достижения цели исследования по определению степени пространственной корреляции рассчитывался индекс пространственной автокорреляции Морана и многофакторный индекс Гири. Пространственный и эконометрический анализ стран ЕС во время COVID-19 позволил им прийти к выводу, что первоначальная реакция ЕС на пандемию отражала националистические стратегии самопомощи, а не совместный европейский подход на более ранних стадиях пандемии. Тем не менее ЕС продемонстрировал относительно более высокий уровень устойчивости внутрирегиональной торговли на фоне негативных последствий пандемии COVID-19.

Ключевые слова: пространственный анализ, региональная интеграция, Европа, COVID-19

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Introduction

The COVID-19 has affected the global environment and posed a challenge to the regional integration. The initial EU's response to the pandemic looked uncoordinated, thus, undermining trust in the EU and questioning

European cohesion. Although the EU obviously represents a successful Western-type integration bloc, unique by its model and level of development, the nationalist reactions of the governments of EU members to the COVID-19 crisis lacked the obvious political will to keep regional integration a priority in times of a global crisis with states preferring self-interest and self-isolation to joint action. Regional integration is impossible without different forms of connectivity subverted by the governments' isolationist policies during the time of the pandemics

The nature of pandemics implies a spatial logic of dissemination with inevitable consequent economic slowdown resulting from the break of supply chains. The spatial dimension of the pandemics makes international regions and regional integration blocks an interesting object for hypothesis-testing. COVID-19 has brought a new wave of geography studies into International Relations studies, adding up to geopolitics, regional integration and migration studies (Bailey et al., 2020). Most COVID-19 studies use, however, spatial analysis at the subnational level to explore different social vulnerabilities (Dodds et al., 2020), with very few exploring the global (Zhou et al., 2020) or regional scale, mostly in relation to international tourist flows.

Contrary to most events in the social sphere, the COVID-19 pandemic is quite an objective and measurable shock. Although COVID-19 has had different epidemiological outcomes across the world, an objectively observable consequence is the closure of national borders and interruption of cross-border flows.

The authors approach COVID-19 as a perfect stress test for integration blocks. It reveals, first, the economic connectivity within the integration blocks and their consolidating power (the ability to consolidate) to prevent or reduce the spread of the virus, on the one hand, and contribute to quick recovery of the most affected economies, on the other. The reaction of regional integration blocs to the COVID-19 pandemic may depend on preconditions of regional integration effects in two spheres: geography and politics.

Academic debates often concentrate on the geography factor as a prerequisite for successful regional integration. It is a specific expression of Waldo Tobler's first law of geography, according to which 'everything is related to everything else, but near things are more related than distant things' (1970). In other words, the proximity between countries creates greater interdependence between them, and therefore contributes to greater interaction, which can ultimately lead to the formation of a trade and economic association. The numerous empirical studies and gravity equations prove the negative correlation between distance and the scale of trade cooperation.

The same principle underlies the convergence theory, in which even initially different countries begin to converge due to geographical proximity and, experiencing common risks, tend to form similar economic responses to them. The EU integration experience proves the positive correlation between real economic convergence and integration success (Ben-David 1993; Neven, Gouyette 1995; Yin, Zestos, Michelis 2003). However, the relationship between economic convergence and regional integration success is widely debated within the concept of 'new regionalism' (Schadler et al. 2006; Halmai, Vásáry 2010; Cuestas, Mercedes, Ordonez 2012; Arapova 2015; Recher, Kurnoga 2017). Experts have opposite views on whether economic convergence is a precondition for integration.

As for the political factor, mainstream international relations theories do not provide a toolkit of specific measurements to quantity the efficiency of regional organizations and their resistance to shocks.

Geographical proximity is a precondition for promoting integration: it turns out that it is easier for neighboring countries to agree on cooperation than it is for more distant ones to do so. This may be due to common history, cultural proximity, and closer established trade contacts (due to the lower logistics costs), but in our opinion, the key factor is the similar economic indicators of states, which prompts them to look for common answers to similar challenges.

According to our hypothesis, geographically close countries experiencing similar challenges will be more prone to economic integration and more resilient to crises. In the language of spatial statistics, this hypothesis would mean that countries experiencing similar economic challenges should form a localized cluster of high (or positive) spatial autocorrelation.

An epidemic is a classic example of a phenomenon spreading in accordance with Waldo Tobler's 'first law of geography': the closer you are to the source of the contagion, the higher the risk of contracting the disease (Munasinghe and Morris, 1996). In our study we apply spatial analysis to discover the trends in pandemic spreads in the EU. Thereby, our approach is to analyze the collective behaviour of the integrating countries during the external epidemiological crisis and their capability to respond to the manifestations of the crisis as 'an organic whole'.

Materials and Methods

In a perfect case, an epidemic spreads spatially from neighbour to neighbour (in a pandemic, from neighbouring state to neighbouring state); in other words, it has an absolute spatial autocorrelation (which equals 1) (Marshall 1991). In today's world, however, there are also social spatial structures (state borders, roads, agglomerations, etc.) that are superimposed on the physical space; those structures reduce the degree of spatial autocorrelation in the spread of a disease.

There are several indexes and methods for determining spatial autocorrelation, but the most popular are those put forward by Moran and Geary. To assess the research goal in order to determine the degree of spatial correlation, we calculated Moran's Spatial Autocorrelation Index The following formula was used:

$$I = \frac{N}{W} \frac{\sum_i \sum_j w_{ij}(x_i - \acute{x})(x_j - \acute{x})}{\sum_i (x_i - \acute{x})}$$

where i, j are units, x_i and x_j are the values of units i and j, $\acute{x}$ is the sampling average for all units, w_{ij} is the weight of spatial ties between units i and j, *N* is the number of units, W is the sum of spatial weights (Cliff, Ord 1973). Simply put, Moran's I assesses the correlation between a phenomenon's level in the country under analysis compared to neighbouring states.

Our analysis is based on data from worldometers.info (URL: https://www.worldometers.info/coronavirus/ (accessed on July 06, 2020)), an independent statistics agency; it has data on 213 states and territories as of July 5 2020, when the epidemic had already penetrated deeply across almost the entire world. Mid-summer 2020 can be considered as the end of the first wave COVID-19 in Europe. It was the first wave of the pandemic that became a perfect stress test for connectivity within regional integration blocks.

For our analysis, we selected data on the cumulative number of deaths per 1,000,000 persons; other figures may not be used for comparison owing to differences between countries in total population numbers and in the numbers of recorded COVID cases.

At the next stage of verifying our hypothesis, we used the method of calculating Local Indicators of Spatial Autocorrelation (LISA). Moran's I assesses spatial autocorrelation for the total data; however, for the purposes of our research, we needed to weigh the spatial autocorrelation between adjacent units. For that purpose, we calculated LISA. This method identified four local clusters:

– *high-high* – spatial autocorrelation cluster with high phenomenon indicators,

– *low-low* – spatial autocorrelation cluster with low phenomenon indicators,

– *high-low* – cells where statistically one would expect spatial autocorrelation with high phenomenon indicators, while in fact they are not observed,

– *low-high* – cells where statistically one would expect spatial autocorrelation with low phenomenon indicators, while in fact they are not observed (Ord, Getis 1995).

Accordingly, if our hypothesis is true, regional integration groups with a denser network of social interactions should have shown up on the spatial autocorrelation plot as high-high clusters, i.e., they would show a spatial cluster of high mortality rates per 1,000,000 of the population relative to their neighbours.

The following formula was used for the calculations:

$$L = \frac{N}{\sum_j \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(z_i - \acute{z})(z_j - \acute{z})}{\sum_i (z_i - \acute{z})^2}$$

where N is the number of cells, z_i is the calculated indicator for cell i, while w_{ij} is the assessment of spatial weights reflecting whether i and j are neighbours; if they are not, it equals 0, and if they are, it equals $\frac{1}{|\delta_i|}$, where $|\delta_i|$ is the number of neighbours of cell I (Anselin 1995). LISA values were mapped for countries with p-value significance less than 0.05

In addition to the analysis of the established spatial social structures, we have also set ourselves the task of analyzing states' reactions to the pandemic. Did neighbours within regional integration unions act together? If the virus spread in a chain reaction within a region, then high-efficiency integration instruments should have resulted in a coordinated joint response. For our indicator, we selected the cumulative number of tests per 1,000,000 persons (based on data from worldometers.info as of 5 July 2020)

As we can see from the formula, the Moran's I (Moran 1948) method does not allow us to estimate spatial autocorrelation from a set of parameters at once, so the Geary spatial autocorrelation index was used for this study, which is due to the possibility of conducting a multi-factor analysis in it. In modern science, less attention is paid to the method of determining the spatial autocorrelation by the Geary's I than to the method of determining the spatial autocorrelation of Moran's I. At the same time, the Geary method is an interesting alternative, since it has a different mathematical essence. The Geary index is not limited to linear relationships, but is based on the square of differences and is therefore suitable for determining multidimensional spatial autocorrelation. (Sawada). Let us see what the Geary index looks like in the form of a mathematical formula:

$$LC_i = \sum_j w_{ij}(x_i - x_j)^2$$

where w_{ij} is a matrix of spatial weights, x_i and x_j are the selected metrics for different objects in space.

While multi-factor Geary's Index is calculated according to the following formula:

$$LC = \sum_{h=1}^{m} \sum_j w_{ij}(x_{hi} - x_{hj})^2$$

where m is the analyzed variables, and h is the summation index. Values are analyzed for country i and its neighbors j using the matrix w_{ij} (Anselin 2019).

Since we assume that neighboring countries should be similar in terms of the range of economic challenges they face, we decided to use the multi-factor Geary index. The following key economic variables were selected as parameters: GDP by PPP per capita; public debt; labor productivity; poverty rate; Gini index; and unemployment rate. Data was analyzed for UN member states.

To perform autocorrelation analysis, we had to set neighborhood parameters for countries (the neighborhood weights matrix). There are two basic models for defining a neighborhood: by adjacency and by metric. Both models were used for better verification.

Adjacency was determined by the "queen's rule," whereby any contact of countries is counted as a neighborhood. The disadvantage of this method is that island states that do not share land borders will be ignored in determining their neighborhood.

An alternative method is neighborhood by metric, when you set a conditional value for the distance from the centroid, and neighboring countries are considered states whose centroids fall within this radius. However, with this method, a large statistical error will apply to large and extended states that have distorted data about their neighbors. For the purposes of this study, due to the complexity of the political map of the world, the k-nearest neighbor method was used as an alternative. It sets a fixed number of neighbors for each country, which by default are selected based on proximity to the centroid of the state. If the median number of neighbors of the world's countries by contiguity is the three, then it is customary to calculate the neighborhood for $k = 6$ to take all states into account.

Using the multi-factor Geary's Index, we identified the presence or absence of spatial autocorrelation between the variables described above, reflecting the degree of similar economic challenges. When testing the hypothesis, only data with a p-value score higher than 0.05 was accepted, i.e., for which the probability of statistical error is less than 5%.

Results

Moran's I assesses the correlation between a phenomenon's level in the country under analysis compared to neighbouring states. For the coronavirus epidemic Moran's I was 0.436. This means that the world's spatial social structures curtail the natural principle of spread of disease by about 56%. Indeed, the epidemic emerged in China, spread first to neighbouring states (Japan, South Korea), then jumped a continent to Italy, which became the source of contagion in Western Europe, and thence it jumped to the US and its neighbouring states, and from there to Brazil and its neighbouring states. The latter observation shows that the coronavirus spread in outbreaks, not from state to state, but from region to region; however, once one country was infected, the disease immediately jumped to its regional neighbours.

The latter conclusion led us to our assumption that regional integration groups (EU, EAEU, ASEAN, etc.) had a higher internal network of social interactions, which increases spatial autocorrelation in the spread of the coronavirus. The disease became something of a perfect stress test for regional integration groups: if they are effective, they should have created a dense network of social interactions and trade ties that would fall victim to the coronavirus.

These results show that the states of Western Europe, North and South Americas formed spatial clusters of sorts with high epidemic levels. Simultaneously, the post-communist states of Eastern Europe are not part of the Western cluster. At the next stage of verifying our hypothesis, we used the method of calculating Local Indicators of Spatial Autocorrelation (LISA). The calculation results were mapped on Fig. 1.

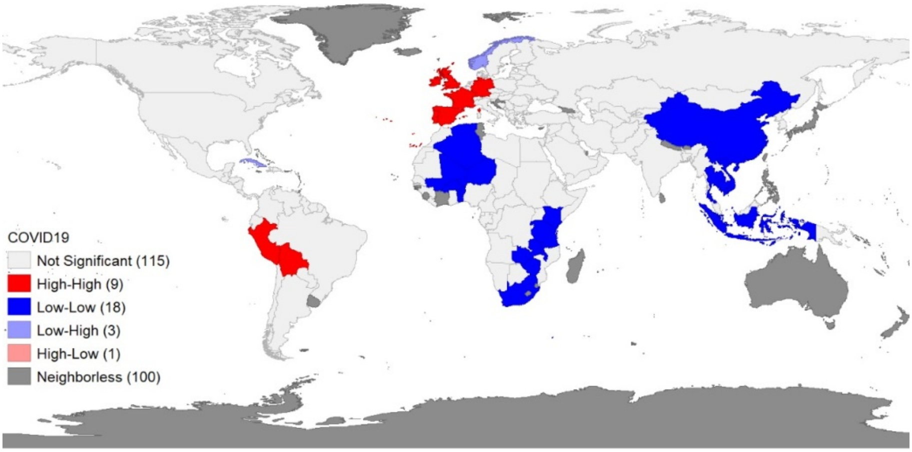

Fig. 1. LISA cartogram by number of coronavirus deaths per 1,000,000 of the population

This method confirmed the data received by the range cartogram. The highest LISA indicators and, consequently, the densest network of social communications between neighbours were exhibited by states of Western Europe.

Now let us calculate LISA to show whether members of regional integration unions acted together. The world demonstrates (Moran's I of 0.382) a spatial autocorrelation between the number of tests. It means that neighbouring states did tend to do the same number of tests per 1,000,000 of the population. For our visualisation, we once again used LISA (Fig. 2).

We can see here that the situation is radically different from our previous calculations. Neither Western European states, nor the states of North or South America demonstrated a common response to the coronavirus challenge despite having a dense network of social interactions. Rare exceptions are constituted by the three Baltic states.

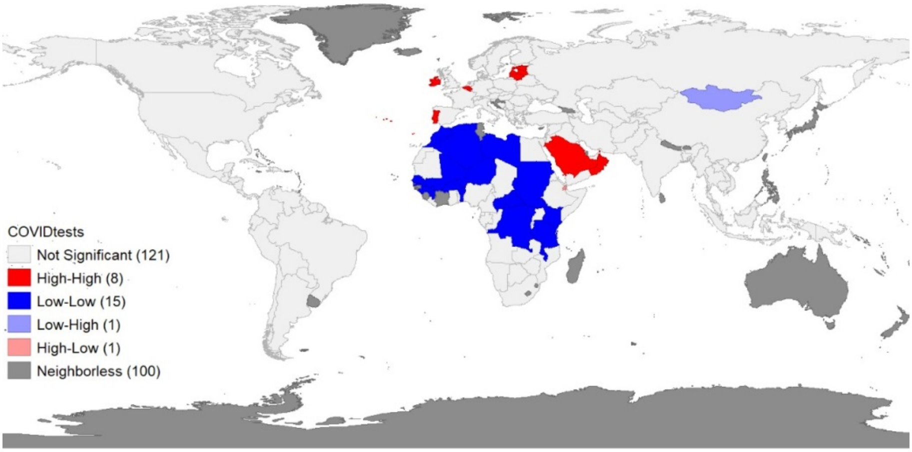

Fig. 2. LISA cartogram by number of coronavirus tests by 1,000,000 of the population

According to the multi-factor Geary Index with both neighborhood models into account, spatial autocorrelation is observed within the following regional groupings: in the EU in Europe (with a stronger core in Eastern Europe); the SAARC in South Asia; SADC in South Africa (with a stronger core in SACU); the ALADI (with a stronger core in the MERCOSUR countries) in South America; and the SICA in Central America. Accordingly, if the hypothesis is correct, then it is precisely in these conditions that geographical homogeneity between neighbors should have increased the resilience of regional blocs against the background of the crisis. However, as a comparison of these results with the previous analysis of empirical data on trade shows, there are no grounds to suggest that there is a correlation of the results obtained. So, in the EU this similarity was only stronger in the Eastern European countries, which had only joined the bloc relatively recently. From this, it can be concluded that geography, as a prerequisite for regional integration, nevertheless cannot be considered an explanatory factor for the resilience of the existing integration blocs.

Concluding Remarks

The overall conclusion is that the spatial analysis produced disappointing results for regional integration throughout the world. Even if individual regions did have dense social interactions networks, the coronavirus used them to spread around the globe, but the states did not use them to produce, together with their neighbours, a common response to the challenge. The low spatial autocorrelation in the EU confirms that the initial EU's response to the pandemic reflected nationalist self-help strategies rather than joint European approach.

On the other hand, the results obtained in this study clearly show, that self-regulation and intraregional adaptation of integration blocs during the crisis depends significantly on the type of regionalism. Intraregional trade in most of the integration blocs contracted at a faster rate during the initial months of the crisis and plummeted further during the second wave. The European Union was the only exception, as it demonstrated relatively strong intraregional trade resistance and ability to mitigate the negative consequences of the COVID-19 pandemic through the intraregional component.

The socioeconomic rapprochement of neighboring countries within the EU (the Western type of regionalism), supported by a high level of institutionalization and political consolidation, led to increasingly stable intraregional trade relations in response to the negative influence of the external crisis.

Nevertheless, since the COVID-19 pandemic is currently an unfinished crisis, these are preliminary results. The conclusions can be further tested on other integration blocs and with the involvement of other groups of indicators describing the socioeconomic similarity of the countries of the region. Besides, it is important to track the long-term regional integration resilience and the long-term adaptive capacity of the integration blocs as soon as the results are available.

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Information about the authors:

Igor Y. Okunev, MGIMO-University (Moscow, Russian Federation).

Ekaterina Y. Arapova, MGIMO-University (Moscow, Russian Federation). E-mail: e.arapova@my.mgimo.ru

Yulia A. Nikitina, MGIMO-University (Moscow, Russian Federation).

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Сведения об авторах:

ОКУНЕВ Игорь Юрьевич – кандидат политических наук, директор, ведущий научный сотрудник МГИМО МИД России (Москва, Россия).

АРАПОВА Екатерина Яковлевна – кандидат экономических наук, директор центра, ведущий научный сотрудник МГИМО МИД России (Москва, Россия). E-mail: e.arapova@my.mgimo.ru

НИКИТИНА Юлия Александровна – кандидат политических наук, ведущий научный сотрудник МГИМО МИД России (Москва, Россия).

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